MODIS SCIENCE DATA SUPPORT TEAM PRESENTATION

July 5, 1991

AGENDA

1. Action Items
2. MODIS Airborne Simulator
3. Scenarios for MODIS Level-1 Processing
4. MODIS Calibration

ACTION ITEMS:

05/03/91 [Lloyd Carpenter and Team]: Prepare a Level-1 processing assumptions, questions and issues list, to be distributed to the Science Team Members and the MCST for comment. (The list, the executive summary, information on the EOS Platform Ancillary Data, and a cover letter were delivered for signature and distribution.) STATUS: Open. Due date 06/07/91.

05/31/91 [Liam Gumley]: Establish a connection with the proper person at Ames Research Center for communication on MAS formats, an interface control document, agreements, etc. STATUS: Open. Due date 07/19/91

06/07/91 [Liam Gumley]: Speak to Alan Strahler, when he returns, regarding his MAS requirements. (Strahler has not yet returned.) STATUS: Open. Due date 07/05/91

06/21/91 [Liam Gumley]: Obtain a copy of all available MAS Level-1B processing software and any existing documentation from the University of Wisconsin at Madison for porting to a system at GSFC. STATUS: Open. Due date 07/19/91

06/21/91 [Liam Gumley]: Generate a complete milestone schedule for conversion, installation and testing of all modules of the MAS Level-1B processing software at GSFC. Draw up an agreement between the SDST and Mike King of what will be done. STATUS: Open. Due date 07/19/91

05/31/91 [Al McKay and Phil Ardanuy]: Examine the effects of MODIS data product granule size on Level-1 processing, reprocessing, archival, distribution, etc. (Work is continuing.) STATUS: Open. Due Date 06/21/91

06/28/91 [Lloyd Carpenter and Tom Goff]: Prepare a detailed list of scheduler assumptions in relation to Level-1 MODIS processing scenarios. STATUS: Open. Due date 07/26/91.

06/28/91 [Lloyd Carpenter]: Prepare a letter to Bill Barnes inquiring as to whether or not the platform ancillary data will be included with the MODIS instrument data. (The letter is ready for signature.) STATUS: Open. Due date 07/05/91.

06/28/91 [Tom Goff]: Prepare an estimate of the total cost of Cadre's Teamwork CASE tools and the Soft Bench umbrella product for the MODIS environment. STATUS: Open. Due date 07/05/91.

ACTION ITEMS FROM SDST MEETING 06/28/91 [Liam Gumley]

The four action items from the last meeting are still pending.

QUESTIONS RAISED AT SDST MEETING ON 06/28/91

(1) Investigate Hierarchical Data Format (HDF).

Harold Geller provided documentation received from Archie Warnock concerning the HDF specifications. A summary follows, which consists mainly of quotations from two HDF documents. These documents are

NCSA HDF Specifications: National Center for Supercomputing Applications, March 1989.

NCSA HDF Calling Interfaces and Utilities: National Center for Supercomputing Applications, November 1989.

These documents were obtained from the NCSA Internet site by anonymous FTP (File Transfer Protocol). The address of this site is ftp.ncsa.uiuc.edu

HDF SUMMARY

The current HDF version is 3.10. The two HDF documents mentioned address version 3.0.

"Hierarchical Data Format (HDF) is a multi-object file format for the transfer of graphical and floating-point data between machines. The design of this format allows self-definition of data content, and easy extensibility for future enhancements or compatibility with other standard formats. HDF was created at the National Center for Supercomputing Applications (NCSA) to serve the needs of diverse groups of scientists working on supercomputing projects of many kinds."

"HDF application software currently comes in three forms: (1) NCSA scientific visualization tools that read and write HDF files, (2) calling interfaces that let you read and write HDF files from within a FORTRAN or C program, and (3) command line utilities that operate directly on HDF files."

"In order to use HDF software, you need access to one of the following computer systems: a Cray with UNICOS, Silicon Graphics system with UNIX, an Alliant with CONCENTRIX, a Sun System 3 with UNIX, a VAX terminal with UNIX, a Macintosh with MacOS, or an IBM PC with MS-DOS, or compatible model."

The two documents mentioned above total over 200 pages. The source code needed to construct the HDF library amounts to over 19000 lines of C code. It is possible to call HDF routines from either FORTRAN or C.

Recommendation: An estimate needs to be made of the time and resources required to implement HDF for the MAS Level-1B data. Consideration will need to be given to

(1) Obtaining the latest version of the HDF source code,
(2) Obtaining the latest version of the HDF documentation,
(3) Understanding the HDF structure,
(4) Compiling the HDF source code,
(5) Testing the HDF calling interfaces and utilities,
(6) Converting the MAS Level-1B data to HDF,
(7) Testing the HDF MAS data for compatibility with the HDF calling interfaces and utilities,
(8) Documenting the HDF access routines for MAS data users,
(9) Providing HDF technical and programming support to the MAS data users on different processing platforms.

MAMS Intermediate Tape Format 07/02/91

The basic storage unit is a 16 bit integer (word). This corresponds to a FORTRAN-77 INTEGER*2 data type. Values stored as 32 bit integers or 8 bit integers are indicated. The following description of a data record is for ONE channel. Each of the 12 MAMS channels has this same record format. An AMES Level-1A MAMS tape will contain 12 of these data records per physical tape block. This comprises all of the MAMS instrument data for one scan line. Aircraft INS data is not included.

Data record length = 430 words (860 bytes)
Tape block length = 12 x 430 words = 5160 words (10320 bytes)

Word #	Description of contents
1	Data Frame Status. Zero indicates good data. Bits are set to 1 to indicate errors as follows: Bit Position — Meaning 1 — Bad digit in scanline count 2 — Bad digit in IRIG time code 4 — Bad digit in thumbwheel data 8 — Bad digit in reference temperature 16 — Incorrect channel 64 — Bad sync word 128 — No match for end-of-frame code (last word) sign — Set to 1 if any other bit set
2	Run Number
3-4	Scanline count (32 bit integer)
5-6	Panel Thumbwheel Switches (32 bit integer)
7	Black Body 1 Thermal Reference Temperature (degrees C x 100)
8	Black Body 2 Thermal Reference Temperature (degrees C x 100)
9	Scan Speed (x 10)
10	GMT hours
11	GMT minutes
12	GMT seconds (x 10)
13	Set to 100 always
14	S-Bend 0 = no S-Bend, 1 = S-Bend

Word #	Description of contents
15	Gain value (x 1000)
16	Channel number
17-18	Time (GMT) expressed as 7 digit number (32 bit integer) (Hours x 100000 + Minutes x 1000 + Seconds x 10 = HHMMSSS)
19	Black Body 1 Radiance Count
20	Black Body 2 Radiance Count
21	Aircraft Roll Count (signed 16 bit integer) Positive is right 0.03 degrees per count, 0.06 degrees per pixel, therefore two counts per pixel
22-25	Filler
26	Byte 1: Black Body 1 Radiance Count (same as word 19) Byte 2: First 8-Bit Digitized Video Pixel Value
27-383	8-bit Digitized Video Pixel Values (two per word)
384	Byte 1: Last 8-Bit Digitized Video Pixel Value Byte 2: Black Body 2 Radiance Count (same as word 20)
385-430	Filler

Proposed MAS Level-1B record format 07/02/91

The basic storage unit is a 16 bit integer (word). This corresponds to a FORTRAN-77 INTEGER*2 data type. Values stored as 32 bit integers are indicated. This record contains all the MAS data for one scan line, including engineering data, all 12 channels of radiance data, calibration data, geolocation data, and aircraft INS data.

Record length = 9300 words (18600 bytes)

Word #	Description of contents
1	Data Frame Status. Zero indicates good data. Bits are set to 1 to indicate errors as follows: Position Meaning 1 Bad digit in scanline count 2 Bad digit in IRIG time code 4 Bad digit in thumbwheel data 8 Bad digit in reference temperature 16 Incorrect channel 64 Bad sync word 128 No match for end-of-frame code (last word) sign Set to 1 if any other bit set
2	Run Number
3-4	Scanline count (32 bit integer)
5-6	Panel Thumbwheel Switches (32 bit integer)
7	Scan Speed (x 10)
8	GMT hours
9	GMT minutes
10	GMT seconds (x 10)
11	S-Bend 0 = no S-Bend, 1 = S-Bend
12	Aircraft Roll Count (signed 16 bit integer) Positive is right 0.03 degrees per count, 0.06 degrees per pixel, therefore two counts per pixel
13-728	Calibrated radiances for channel 1 (716 pixels) (units and scaling TBD)

Word #	Description of contents
729-1444	Calibrated radiances for channel 2 (716 pixels) (units and scaling TBD)
1445-2160	Calibrated radiances for channel 3 (716 pixels) (units and scaling TBD)
2161-2876	Calibrated radiances for channel 4 (716 pixels) (units and scaling TBD)
2877-3592	Calibrated radiances for channel 5 (716 pixels) (units and scaling TBD)
3593-4308	Calibrated radiances for channel 6 (716 pixels) (units and scaling TBD)
4309-5024	Calibrated radiances for channel 7 (716 pixels) (units and scaling TBD)
5025-5740	Calibrated radiances for channel 8 (716 pixels) (units and scaling TBD)
5741-6456	Calibrated radiances for channel 9 (716 pixels) (units and scaling TBD)
6457-7172	Calibrated radiances for channel 10 (716 pixels) (units and scaling TBD)
7173-7888	Calibrated radiances for channel 11 (716 pixels) (units and scaling TBD)
7889-8604	Calibrated radiances for channel 12 (716 pixels) (units and scaling TBD)
8605-8616	Black Body 1 Reference Temperatures for channels 1-12, 1 channel per word (12 values) (degrees C x 100)
8617-8628	Black Body 2 Reference Temperatures for channels 1-12, 1 channel per word (12 values) (degrees C x 100)
8629-8640	Gain values for channels 1-12, 1 channel per word (12 values) (x 1000)
8641-8652	Black Body 1 Radiance Counts for channels 1-12, 1 channel per word (12 values) (units and scaling TBD)
8653-8664	Black Body 2 Radiance Counts for channels 1-12, 1 channel per word (12 values) (units and scaling TBD)

Word #	Description of contents
8665-8676	Calibration slopes for channels 1-12, 1 channel per word (12 values) (units and scaling TBD)
8677-8688	Calibration intercepts for channels 1-12, 1 channel per word (12 values) (units and scaling TBD)
8689-8834	Latitude for every 10th pixel (32 bit integers) i.e. for pixel numbers 1, 10, 20, 30,....., 700, 710, 716 (73 values) (degrees, scaling TBD)
8835-8980	Longitude for every 10th pixel (32 bit integers) (73 values) (degrees, scaling TBD)
8981-9053	Sensor zenith angle for every 10th pixel (73 values) (degrees, scaling TBD)
9054-9126	Sensor azimuth angle for every 10th pixel (73 values) (degrees, scaling TBD)
9127-9199	Solar zenith angle for every 10th pixel (73 values) (degrees, scaling TBD)
9200-9272	Solar azimuth angle for every 10th pixel (73 values) (degrees, scaling TBD)
9273	INS aircraft heading (degrees, scaling TBD)
9274	INS aircraft altitude (units and scaling TBD)
9275	INS aircraft speed (units and scaling TBD)
9276	INS aircraft roll (units and scaling TBD)
9277	INS aircraft pitch (units and scaling TBD)
9278	INS aircraft yaw (units and scaling TBD)
9279-9300	Unused (zero filled)

SCENARIOS FOR THE MODIS LEVEL-1A AND LEVEL-1B PROCESSING

5 July 1991

1. Normal Processing:

Normal MODIS Level-1A and -1B processing will be done as required input data elements are received and as the necessary EOSDIS compute resources become available for MODIS use. In normal operations, processing of a MODIS data granule will begin when a complete set of instrument data packets for the granule has been received and required platform ancillary data for the granule is available.

Level-0 MODIS data (instrument data packets) will be received and stored at the local DADS until Level-1 processing begins. When MODIS processing begins, the EOSDIS scheduler will prefetch the required items from the heirarchical data storage system and initiate MODIS processing as processing hardware becomes available.

The CDOS will usually deliver Level-0 data in blocks of one, or at most, two orbits of data. During CDOS processing, data received at the ground station has been error corrected, if possible, has been error flagged, if correction is not possible, and has been bit order reversed if time reversal of received data is required. CDOS processing has also accounted for all received packets, identified any missing data items, and eliminated any duplicate data packets that may have been created during successive playbacks of the on-board tape recorders.

The MODIS Level-1A product is primarily intended to provide a permanent record of MODIS instrument data; it can be reversed to recover Level-0 data, if required. The Level-1A product receives minimal processing. During Level-1A processing, spacecraft ancillary data will be appended but not applied to the instrument data to provide a single, integrated source of all the data required to complete Level-1 processing, successive instrument packets are concatenated to produce the Level-1A data granule, and metadata is generated to facilitate data storage and user retrieval of data. By present plans, data will not be unpacked (byte-aligned) during Level-1A processing.

The primary functions performed during Level-1B processing include the Earth-location of MODIS pixels and the radiometric conversion of sensor outputs to obtain physical radiances at the sensor (sensor calibration). Level-1B processing will also include quality checks to assure proper MODIS instrument operation. Results of the Level-1B instrument checks will be routinely provided to instrument controllers and the MCST. Instrument controllers and MCST personnel may access the results obtained from Level-1B instrument checks on a demand basis.

2. Quick-Look Processing:

In most cases, the need for quick-look processing can be anticipated. For example, in planned field experiments, an early look at the MODIS data may be a key element in the decision making process directing the ground portion of the experiment. The investigators will coordinate their quick-look processing requirements with the MODIS Team Leader who will provide final approval and coordinate the effort with CDOS and other elements of the EOSDIS.

A MODIS quick-look processing request will be sent to the EOSDIS specifying which data are to be processed. The EOSDIS will adjust priorities and expedite the flow of the data through the CDOS. The SCA will initiate the MODIS Level-1A quick-look processing soon after the data are available.

Quick-look processing may require time-ordering, redundancy elimination, and quality control measures not normally required for standard MODIS processing. However, quick-look processing will be executed using the same version of software as normal processing, and the Level-1A software will be designed to perform these functions.

Platform ancillary data may not be available in time for quick-look processing. In this case an alternate source, such as a predicted ephemeris, will be specified and made available by the EOSDIS for the required platform position and attitude data.

The Level-1A process will notify the scheduler when quick-look processing is completed. The scheduler will then initiate the MODIS Level-1B quick-look processing, which will be executed using the same version of software as normal Level-1B processing.

3. Metadata Generation:

MODIS metadata consists of information describing the MODIS data which is obtained or derived from the data sets, and which provides an understanding of the content or utility of the data set. Metadata may be used to select and evaluate data for a particular scientific investigation.

Beginning at Level-0, each successive processing level will generate and append metadata as part of the data product. The metadata associated with the input product are updated to reflect further derived information. Previous metadata items are retained to allow backward tracking of information to the original source. This information can be used for debugging and quality assurance determination. For example, the CDOS Reed-Solomon error statistics can be maintained with the mapped Level-3 product as an indication of the quality of the original data that went into the product. Metadata derived in the beginning of the processing chain will provide information which is useful for the generation and assessment of products later in that chain.

Care must be taken in the interpretation of metadata in some cases. For example, error statistics for a granule of Level-1A data could be misleading when each Level-1A granule

is subdivided into several granules at Level-1B. Some of the Level-1A statistical information may not be correct when applied to the subset of data which went into a particular Level-1B granule, etc. The reverse situation occurs, for example, when many Level-2 granules are used as input to a Level-3 process which generates an average value and a secular rate of change for some parameter. However, with a complete trail of metadata information, the user should be able to trace the heritage of his data and properly interpret his results.

4. Browse Data Generation:

Since the MODIS science team members have not indicated a requirement for Level-1A browse, no MODIS Level-1A browse products have been planned.

The MODIS Level-1B browse process will be designed for easy adaptation to future technology developments without affecting the standard Level-1B process. To this end, the MODIS Level-1B browse process will be separate from the normal Level-1B process. After each execution of the Level-1B process, the Level-1B browse process will be initiated to generate the standard Level-1B browse product.

Specifics of the Level-1B browse product will be defined by the MODIS science team. This product might include, for example, a time sequence of "scenes", each of which is generated by sub-sampling the pixels of a rectangular area on the earth's surface. For each pixel, the recorded signals would be included (at reduced resolution) for a specified subset of the available frequency bands. Users would "call up" these browse scenes at will.

If the EOSDIS supports an extended browse product, then users could, at any time, request that special Level-1B browse scenes be generated from archived Level-1B data. In this mode, for example, the user would specify times, earth locations, and frequency bands to be included in the browse scene. The success of this extended browse capability could reduce the need for archiving standard Level-1B browse products.

5. Processing Previously Missing Data:

In normal operations, processing of a MODIS Level-1A or -1B data granule includes all of the data which should be in the granule. However, there will be occasions when some of the data are missing at the time of normal processing. In fact, this will happen frequently when the time boundaries of blocks of Level-0 data scheduled for Level-1A processing do not correspond to Level-1A granule boundaries.

If the previously missing data correspond to one or more complete granules, they will be processed in the normal mode. Otherwise, special handling will be required.

One possible scenario for processing previously missing data would be to have all of the data processed to Level-1A as it is scheduled, and then have the incomplete granules combined by a utility process. A shortcoming of this scenario is that, in some cases, not

all of the data in a granule would have been processed at the same time. In fact, data within a granule could have been processed using different versions of the software.

Another possible scenario would be to reprocess all of the data within a granule whenever previously missing data is received. If this causes excessive inefficiency, the reprocessing could be done for only those cases where different versions of the software or the ancillary data are involved.

6. Reprocessing:

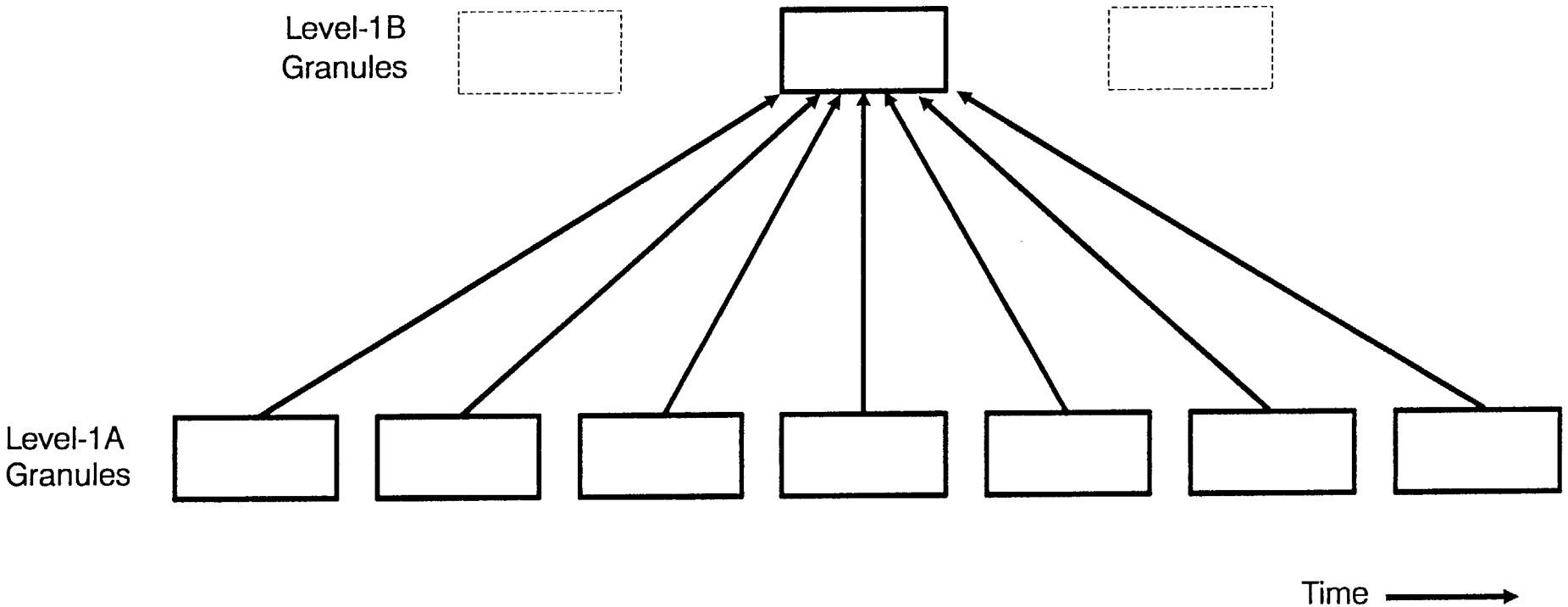
A. New Version of Software:

It is unlikely that the original, at-launch, version of the software will be used throughout the mission without revision. When significant changes are needed, the Configuration Control Board (CCB) will authorize a new version of the software. Generally, this will require reprocessing of all of the previous data, starting at the level of the software revision, and continuing through all higher levels, to provide consistency. Each data granule will contain accounting information which will provide processing traceability through all levels.

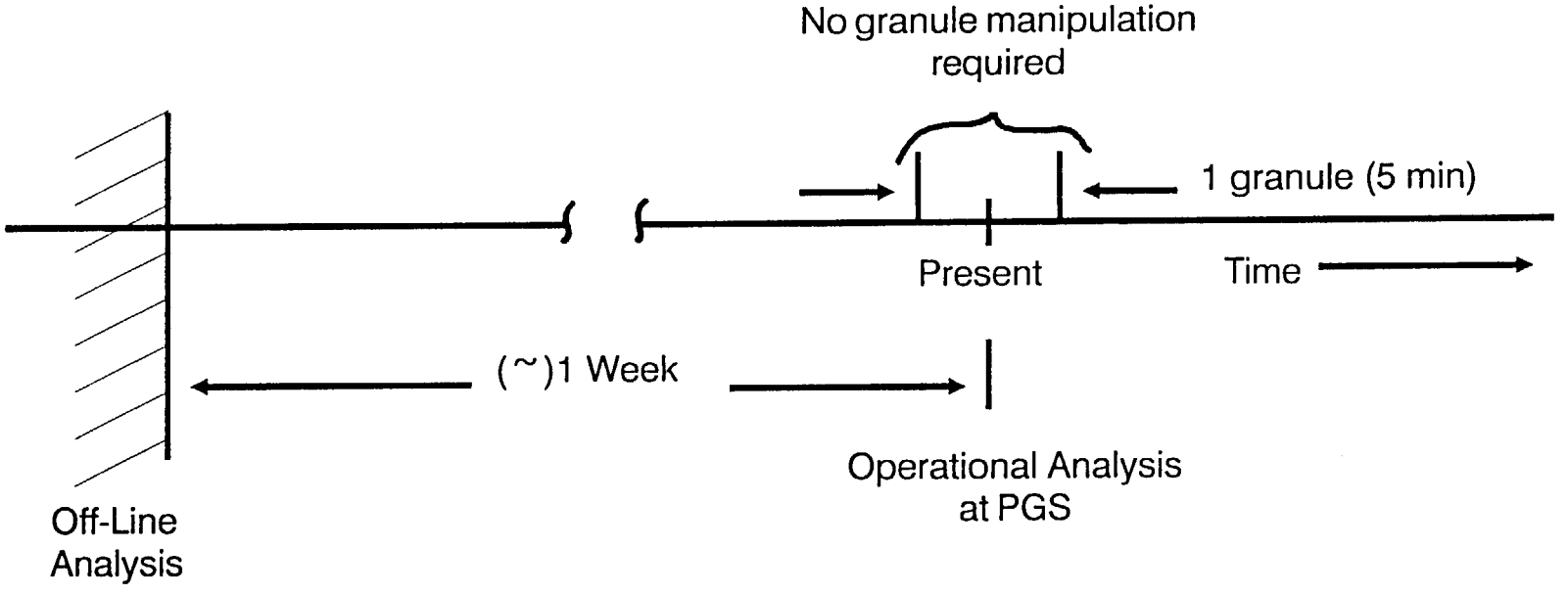
B. New Version of Ancillary Data:

In the Level-1A processing, the platform ancillary data are appended to the Level-1A data without making any changes to the MODIS instrument data. If more accurate spacecraft position and attitude data become available later, and it is required that the more accurate data be used for earth location, etc., then the replacement can be made using utility software, without reprocessing the instrument data. This replacement will be reflected in the version number of the Level-1A product, and in the metadata.

Potential Calibration Data Flows



Time Domains for Calibration Analysis



QUESTIONS

- Is calibration information obtained within a week of an observation but not included within the observation granule itself needed to characterize MODIS behavior at the time of the observation?

- If yes, how should the required information from multiple granules be provided for Level-1B processing?

ALTERNATIVE 1

- Access complete Level-1A granules

ALTERNATIVE 2

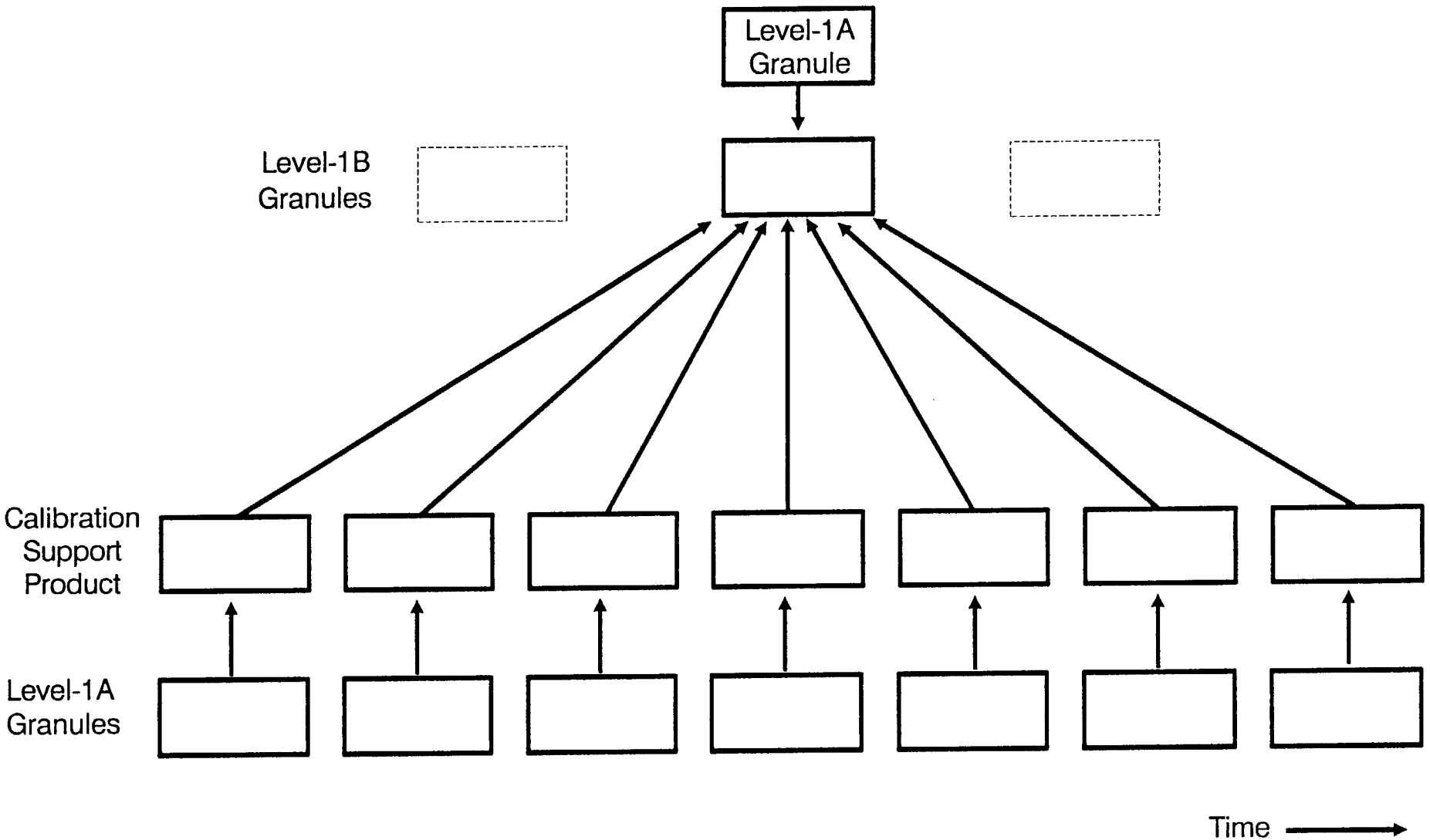
- Generate calibration support product from Level-1A granules

  - Extract calibration data from instrument bit stream.

  - Or apply calibration processing to each granule and retain results

  - Calibration support product may be retained in archives or discarded after processing.

Data Flows with Calibration Support Product



	A	B	C	D	E	F
1	Revised on		6/10/91			
2						
3						
4		Num.	Day	Night		Health/Safe
5	Ground Frames		1007	16		
6	Dark frames		5	5		
7	calibration frames		12	12		
8	**total frames**		**1024**	**33**		1
9						
10	**#bits/frame**					
11	frame(12 bit A/D plus gain bit)		13260	13260		13260
12	tilt		18	18		18
13	scan		18	18		18
14	time tag		64	64		64
15	**Total Bits per Frame**		**13360**	**13360**		**13360**
16						
17	**bits/swath**					
18	frames (total frames * total bits/frame)		13680640	440880		13360
19	electronic reference (30*13 bits):		390	390		390
20	**thermistors (48*8 bits each)**	48				
21	PDU	4	32	32		32
22	C&DH (Side which is on)	4	32	32		32
23	Drive Box	4	32	32		32
24	Detector Drive Box	4	32	32		32
25	Thermal Box	2	16	16		16
26	Detector Power Supply	4	32	32		32
27	Signal Processing Box	4	32	32		32
28	Mechanisms (2 ea for the four mechanisms)	8	64	64		64
29	Calibration Spheres	4	32	32		32
30	PMP	2	16	16		16
31	Optical Bench	8	64	64		64
32	Photo-diode Calibration(4*12 bits)		48	48		
33	Diffuser Encoder		4	4		48
34	Aperture Encoder		8	8		4
35	**Relay Positions (256 * 1 bit each):**	256				8
36	Misc.	32				
37	PDU	32	32	32		
38	Mechanism Drive	32	32	32		32
39	C&DH (Side which is on)	32	32	32		32
40	Thermal Box(32)	32	32	32		32
41	Detector Drive Box(32)	32	32	32		32
42	Analog Processing Box(32)	32	32	32		32
43	Detector Power Supply(32)	32	32	32		32
44	**Voltages/Currents(96 - 8 bit):**	96				
45	PDU	16	128	128		128
46	C&DH	16	128	128		128
47	Mechanism Drive Electronics	16	128	128		128
48	Detector Drive Electronics	16	128	128		128
49	Analog Processing Electronics	16	128	128		128
50	Thermal Electronics	16	128	128		128
51						
52	Total Bits/Swath (before header):		13682466	441938		64
53	Packet Header (0.68%)		93041	3005	no packets	15218
54	**Total Bits per Swath**		**13775507**	**444943**		0
55						**15218**
56	Scan Mirror Speed (REV/Min)		6.6	6.6		
57	**Total Scan Time (sec)**		**4.545**	**4.545**	**every 3 scans**	6.6
58						**13.636**
59	**Transmitted Data Rate (Bits/sec)**		**3030611**	**97887**		
60						**1116**
61	Orbit Data Rate		day-40%	night-60%		
62	**Average Orbit Data Rate**		**1270977**			**1116**
63						